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Ejector with Gas Propulsion

This application claims Paris Convention priority of DE 102 50 532.2 filed October 29, 2002 the complete disclosure of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

The invention concerns a gas driven ejector, i.e. a jet pump, for generating underpressure, with at least one primary nozzle branch having a driver nozzle with a cross-sectional narrowing, an adjacent receiving nozzle, and a suction line connected to the narrowing.

Conventional ejectors or jet pumps of this type function according to the Venturi principle. The filtered and lubricant-free compressed gas flows via a connecting sleeve and a pressuring gas feed line into the ejector and reaches the driver nozzle where the flow velocity of the compressed air serving as the driver gas is increased to supersonic speed in the narrowing. After exiting the driver nozzle, the air expands and flows into a diffuser and from there, optionally via a sound absorber, to the outside thereby producing a vacuum in a chamber surrounding the driver nozzle with air being pumped via a suction line feeding into the chamber. The pumped air and the driver gas introduced into the ejector both exit the ejector via the expansion section.

With respect to other vacuum pumps, these jet vacuum pumps advantageously have no rotating parts and maintenance and wear are therefore minimum. Moreover, they cannot explode since they function purely pneumatically. In addition, their construction is simple and they can be installed at any location. They do not generate heat and can be connected and disconnected at any time to save energy. Moreover, the vacuum can be generated quickly using short lines between e.g. a suction gripper and the ejector. The compact construction, the low weight and the ability to combine several functions in one device play an important economic role in the field of construction, work preparation, purchasing, mechanical processing, assembly, putting into operation and spare part supply.

In view of the above, it is the underlying purpose of the invention to provide a gas propulsion ejector which ensures good suction performance in a straightforward manner with low driver gas consumption.

SUMMARY OF THE INVENTION

This object is achieved in accordance with the invention in that at least one connectable secondary nozzle branch is provided which has a driver nozzle with a narrowing and an adjacent receiving nozzle, wherein the narrowing of the secondary nozzle branch is connected to a suction line when the nozzle branch is connected, with a closing instrument being disposed upstream of the at least one secondary nozzle branch to

connect/disconnect the secondary nozzle branch in dependence on the input pressure of the driver gas in the ejector.

In accordance with an embodiment of the invention, the second nozzle branch, e.g. the secondary nozzle branch, is only connected when the inlet pressure is high. The second Venturi nozzle is then activated to provide a very high suction capacity and associated high vacuum. In this case, both Venturi nozzle suction capacities are combined to evacuate e.g. the feed line to a suction gripper. Since the second Venturi nozzle is connected only when required, no driver gas is wasted. In this fashion, the modular connection of one or more additional Venturi nozzles individually adjusts the suction performance while providing sufficient flow velocity at high as well as low required suction performance to always ensure safe operation of the evacuation process.

Alternatively, the secondary nozzle branch may be connected when the inlet pressure is below a certain switching pressure. In this case, both nozzle branches are used only when the inlet pressures are low and evacuation takes place only via one nozzle branch, i.e. the primary nozzle branch when the inlet pressure is high.

In accordance with an embodiment, the closing instrument may be held in a first position via a preloading force which counteracts the inlet pressure of the driver gas. The closing instrument may e.g. be a bistable 2/2 way valve. In this case, the preloading force is provided by a spring which acts e.g. on a piston. Depending on whether the secondary nozzle branch is to be connected at low or high working

pressures, the first position is defined as the open or closed position. The stop valve or closing instrument is adapted to the desired switching direction. When the switching pressure is reached, the inlet pressure can switch the closing instrument into a second position with that second position being either that state of the closing instrument with which the secondary branch contributes to the suction performance or that state in which it is disconnected, in dependence on the desired switching direction.

The two nozzle branches may also have a common feed line which contains the closing instrument. In most cases, the driver gas is pressurized air.

According to a further embodiment, the primary and the secondary nozzle branch may have a common suction line which may, in particular, be a continuous suction line which communicates with the two nozzle branches. A check valve may be disposed in the suction line between the secondary and primary nozzle branch to prevent leaking of the vacuum generated by the first nozzle branch when the secondary nozzle branch is disconnected. When an underpressure is also generated in the secondary nozzle branch, the check valve opens and the underpressure of the secondary nozzle branch also contributes to the suction performance in the suction line.

Alternatively, at least the secondary nozzle branch, a further nozzle branch, or a group of nozzle branches may each have its own separate

suction line. Towards this end, several suction circuits may be connected or disconnected independently of each other.

The check valve may preferably be a spring-loaded ball valve. The spring forces may be adjusted such that even a small force is sufficient to overcome the spring. In this case, the check valve may already lift off during low suction performance of the secondary nozzle branch. The low spring force is sufficient, since the stop ball is additionally pressed against the closure seat by the underpressure generated when the first nozzle branch is operated to thereby safely prevent leakage. If the spring has a low spring constant, two nozzle branches of equal suction performance may also be operated, since, in this case, the closing element is in a bistable state and the suction line is opened for the second nozzle branch.

The secondary nozzle branch may have the same or a different suction performance than the primary nozzle branch and preferably a higher suction performance, since this ensures complete and simple opening of the check valve. By providing different Venturi nozzles of different types or performance classes, the suction performance effected in the suction line and exhaust connection may be varied to permit reliable adjustment of the required underpressure and evacuation time.

In addition to the above-described two nozzle branches, several primary and secondary nozzle branches, which are connected in parallel, may also be provided, with all primary nozzle branches being connected at the same time and all secondary nozzle branches being connected or

disconnected at a common switching pressure. In addition to the secondary nozzle branch, a tertiary or quaternary nozzle branch may be provided which is disconnected or connected at a further switching pressure other than the first switching pressure, to further improve the regulation and control of the suction performance in accordance with the requirements.

All nozzle branches may be connected to one single suction line, preferably in that the nozzle branches intersect that suction line.

The check valves may be preferably provided only between branches of different connection pressures. In this manner, no check valves are provided between different primary nozzle branches and only one check valve is provided between a group of primary nozzle branches and a group of secondary nozzle branches. If, in addition to primary and secondary nozzle branches, tertiary nozzle branches are also provided, a check valve may be disposed between the primary and the secondary and tertiary nozzle branches.

All components and nozzle branches of the ejector can thereby be disposed within a common housing. The housing may consist e.g. of a material block into which all lines are introduced as bores with the nozzles and valves being inserted into the block and fixed therein with remaining openings being closed by caps. This provides particular advantages for maintenance, configuration, and replacement of individual components.

Further advantages and features of the invention can be extracted from the disclosure. The drawing gives a detailed description of a particularly preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a diagram of connections of an inventive ejector;

Fig. 2 shows an exploded view of an inventive ejector; and

Fig. 3 shows a section through an inventive ejector.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 shows a circuit diagram of an ejector or jet pump, designated in its entirety with 10. The ejector 10 has a primary nozzle branch 12 and a secondary nozzle branch 14. The two nozzle branches are connected to a feed line 16 for a driver gas, wherein in Fig. 1, a common air supply branch 16 branches into the air supply branches 16′ and 16″ for the primary nozzle branch 12 and the secondary nozzle branch 14, respectively. The air supply branch 16′ for the primary nozzle branch supplies driver gas to a first Venturi arrangement 18 of the first supply branch 12. A switching valve 20 is disposed in the second air supply branch 16″ to pass air to the second Venturi arrangement 22 of the second nozzle branch 14 or to close off the air supply line 16″ of the second arrangement 22.

The valve 20 is a bistable 2/2 way valve and is explained in more detail below.

The primary nozzle branch 12 and the secondary nozzle branch 14 are connected to a suction line 24. One single suction line 24 connects to the two nozzle branches 12, 14 in the region of their respective cross-sectional narrowings of the Venturi arrangements 18, 22. A further line, e.g. for a suction gripper, may be evacuated via the suction line 24 which feeds to a suction nozzle 26. A check valve 28 (a spring-loaded ball valve) is disposed in the suction line 24 between the primary nozzle branch 12 and the secondary nozzle branch 14 to prevent leakage of the vacuum of the first nozzle branch 12 in the event that the secondary nozzle branch is not connected.

In the circuit of Fig. 1, the ejector 10 is operated only with respect to the primary nozzle branch 12 as soon as it is loaded with driver gas (compressed air). The valve 20 is thereby held in the blocking position. Acceleration of the compressed air to supersonic speed in the primary nozzle branch 12 generates an underpressure in the region of its cross-sectional narrowing in a chamber surrounding the narrowing, through which the suction line 24 is evacuated. The check valve 28 prevents leakage of vacuum in the chamber.

As soon as the supply pressure in the feed line 16 of the compressed air reaches a predetermined switching pressure for the valve 20, the second, i.e. secondary nozzle branch 14 is opened. At this moment, the air consumption is doubled, as is the suction volume.

As soon as the inlet pressure is reduced, the valve 20 switches back to the blocked position.

A certain switching hysteresis of the valve 20 must thereby be taken into account.

The switching pressure is thereby predetermined by the valve 20.

The structure is explained below using an exploded view of an inventive ejector 10. The ejector 10 is mounted in a housing 29 and can be fixed through the housing 29 to a base e.g. via mounting locations 30.

The two nozzle branches 12 and 14 thereby consist essentially of a receiver nozzle 32 or 34 and a driver nozzle 36 or 38, which are connected to each other via an O-ring 40 and form the Venturi arrangements 18, 22. The cross-sectional narrowing in the driver nozzle 36 or 38 accelerates the compressed air introduced into the feed line 16 to supersonic speed.

A check valve 28 comprising a ball 42 as the closing body and a spring 44 with a low spring constant is disposed between the two nozzle branches 12 and 14 in the suction line 24 which connects the two nozzle branches 12 and 14 and which feeds to a suction nozzle 26. The vacuum generated in the primary nozzle branch 12 is thereby protected from leakage with respect to the secondary nozzle branch.

The suction line 24 is closed on both sides of the housing 29 through which it penetrates using cover flaps 46, in particular plastic lids.

In a particularly simple fashion, the housing 29 is not merely a cover for the individual parts but a material block into which the individual recesses for the feed line etc. such as e.g. the suction line and the compressed air lines of the nozzle branches 12, 14, which intersect the suction line, are machined, wherein only components such as the driver nozzle, the receiving nozzle, and the valves are separate and are inserted into and fixed in the housing block. In this fashion, replacement of the individual component or insert is particularly easy. A jet pump 10 of this type can be easily adjusted to different types or performance classes without having to replace the entire jet pump 10. For cleaning and/or inspection, the individual nozzles 32-38 can be easily removed, cleaned or examined and be subsequently re-installed. Faulty individual parts may be particularly easy to replace.

A 2/2 way valve 20 may be provided in the region of the feed line which comprises a piston 48 which forms a unit together with a piston seal 50 and an O-ring seal 52. The piston is pressed by a spring 54 in the direction of its longitudinal axis, whose spring constant and bias permits adjustment of the switching point. The O-ring 52 thereby seals the compressed air line of the secondary nozzle branch 14 when the piston 48 is in a closed position, i.e. in its first or resting position.

The side of the spring 54 facing away from the piston 48 abuts a plug 56 via which the spring bias can be adjusted.

When the valve 20 is closed, compressed air for the primary nozzle branch 12 can flow unhindered past the switching piston 48. The switching piston has different cross-sections along its length, with the pressure of the flowing compressed air acting on the piston 48, via an annular surface of larger cross-section formed at a front side of the piston 48 in the region of the larger cross-section to oppose the loading direction of the spring 54. The compressive forces of the pressurized air thereby depend on the circular area 51 of the piston 48 at which those forces act as well as on the absolute pressure.

The smaller cross-sectional surface of the piston 48 which corresponds to a corresponding smaller bore in the housing 28 is thereby disposed in the direction of the second 14 nozzle branch.

If there is compressed air in the feed line 16, the piston 48 is loaded with pressure at its surface 51. This force acts against the bias of the spring 54. As the pressure is increased and as soon as the force exerted by the compressed air exceeds the spring force, the piston 48 is moved against the spring force in the direction of the plug and up to a predetermined stop. The feed line to the secondary nozzle branch 14 is thereby opened and the secondary nozzle branch contributes to the suction performance. This doubles the air consumption and the suction volume.

If the supply pressure on the inlet line 16 is reduced, the piston 48 moves back towards the second nozzle branch 14 until the O-ring 52 of

the piston seal 50, piston 48 and O-ring 52 assembly abuts the corresponding bore 53 and the associated surface in the housing block 29 to seal the piston 48 in the position on the conical surface 53.

Fig. 3 shows the ejector 10 of Fig. 2 in an assembled state illustrating the position of the check valve between the nozzle branches 12 and 14.

The pressure forces of the compressed air thereby act on the annular surface 51. The spring force of the spring 54 opposes these pressure forces produced by compressed air. If the pressure forces exceed a switching pressure, the piston 48 is pressed downwards (in the illustration) against the spring 54 and permits passage of compressed air to the second nozzle branch 14.

As soon as the second nozzle branch also produces a vacuum, the ball 42 of the check valve is moved against the spring force of the spring 44 by the vacuum in the second nozzle branch 14 and towards the second nozzle branch 14 to open the passage in the suction line 24, wherein additional vacuum is generated on the suction nozzle 26, e.g. for a suction gripper. The suction performance of the secondary nozzle branch 14 must be greater than or equal to that of the primary branch 12 in order to hold the check valve 28 in the open position.

As soon as the pressure in the feed line 16 decreases, and the piston 48 closes the feed line to the second nozzle branch 14, the ball 42 is pressed back into its valve seat by the force of the spring 44 to close

the suction line 24 in the region of the narrowing of the first nozzle branch 12, thereby preventing leakage.

In this fashion, a second nozzle branch 14 can be connected only when increased suction performance is required and in all other cases, air consumption can be reduced. The air consumption and suction performance can thereby be efficiently controlled.